INSTRUCTIONS

FOR OBSERVING THE

TOTAL ECLIPSE OF THE SUN,

JANUARY 1, 1889.

BY DAVID P. TODD, PH.D.,
Director of Amherst College Observatory.

AMHERST, MASS.
PUBLISHED BY THE OBSERVATORY.
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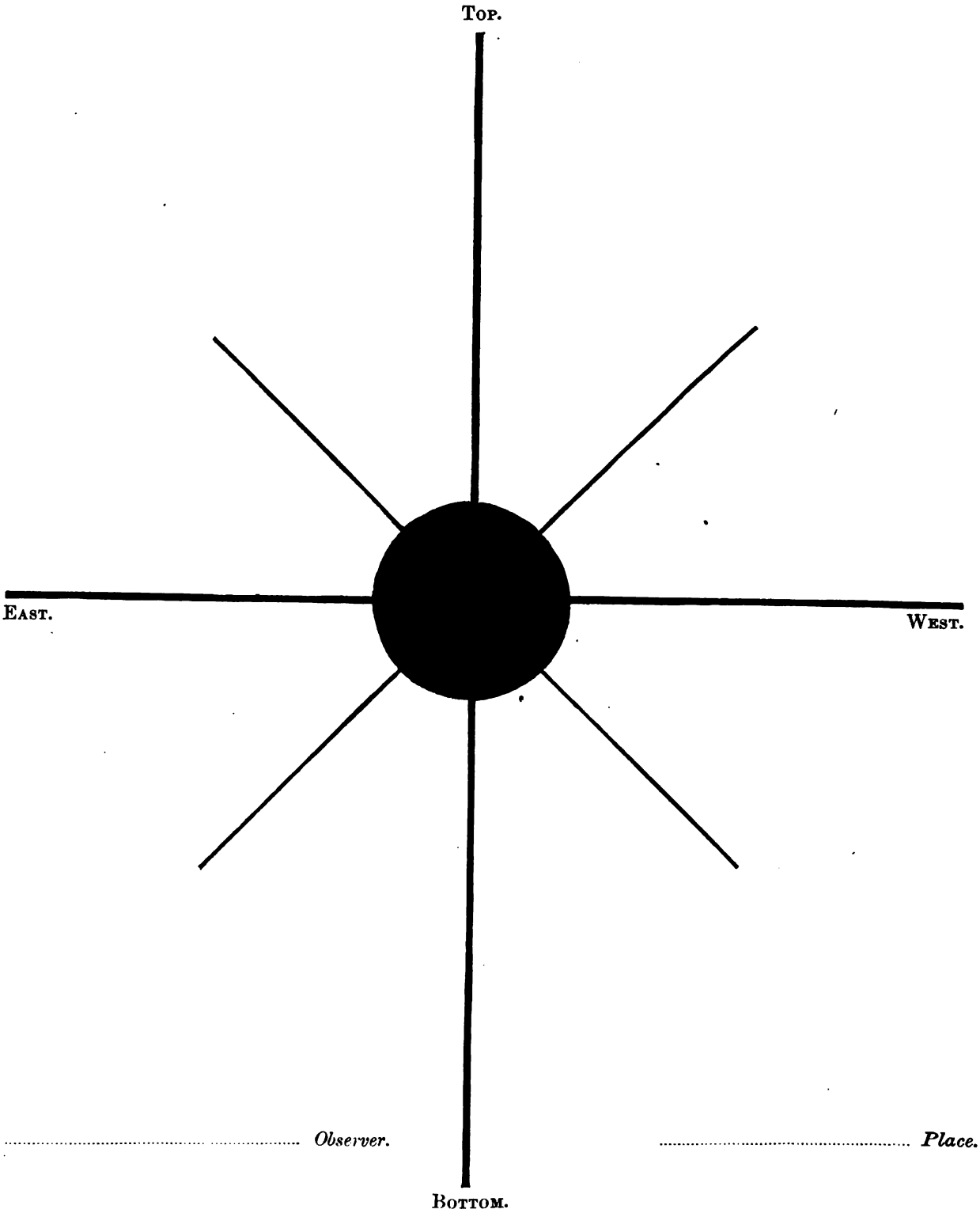

..... *Observer.* ..... *Place.*

INSTRUCTIONS FOR OBSERVING

THE

TOTAL ECLIPSE OF THE SUN.

JANUARY 1, 1889.

THE moon's shadow sweeps across the Northwestern United States on the afternoon of January 1, 1889, causing a total eclipse of the sun which may be observed in the following regions: —

NORTHERN CENTRAL CALIFORNIA.
NORTHERN NEVADA.
SOUTHERN IDAHO.
THE YELLOWSTONE PARK.
SOUTHEASTERN MONTANA.
NORTHWESTERN DAKOTA.
MANITOBA.

Persons inhabiting these localities can make valuable observations of the eclipse by following the directions indicated in this pamphlet.

These observations are not difficult to make; they mostly require no instruments, and but little preparation beforehand.

CENTRAL LINE.

This is the line along which the total eclipse will last the longest. It passes through or very near the following points: —

In *California*, Point Arena, Manchester, Boonville, Ukiah, Upper Lake, Little Stony, Norman, Nelson, Brush Creek, Nelson Point.

In *Nevada*, the north end of Pyramid Lake, Good Hope, White Rock, Columbia, Island Mountain.

In *Idaho*, Rock Creek, Shoshone Falls, Rexburg.

In *Wyoming*, the northwest extremity of Yellowstone Lake.

In *Montana*, Redlodge, Dilworth, Howard, Forsyth, Newton, Ridgelawn.

In *Dakota*, Fort Buford, Little Muddy.

In *Manitoba*, Brandon, Gladstone.

Path of Total Eclipse.

The belt, or path, of total eclipse lies equally on both sides of this central line, and curves thus gradually toward the north. The width of the belt also grows less toward the north and east.

Through California, its average width is about 96 miles. An observer, therefore, in that State would not expect to see the sun entirely obscured unless he were within 48 miles of the central line, on either side.

Through Nevada, the average width of the belt of totality is about 90 miles; through Idaho, about 82; and through Montana, about 66.

Time and Length of Total Eclipse.

On the central line, the time when total eclipse takes place, and the duration of the total phase, are approximately as here given: —

STATE.	Time of Total Eclipse.	Length of Total Eclipse.
	h. m.	m. s.
California . . .	1 48 Pacific Time.	1 57
Nevada	1 55 " "	1 48
Idaho	3 1 Mountain Time.	1 38
Montana . . .	3 6 " "	1 25
Manitoba . . .	4 8 Central Time.	0 12

General Appearance of the Total Eclipse.

Just before the time indicated in the above table, the sun's light will have been nearly shut off by the advancing moon, and it will have become quite dark. The only part of the sun visible will have the form of a crescent, the ends of which will rapidly approach each other as the crescent becomes thinner and thinner.

Immediately after the crescent has vanished, total eclipse will begin, and the luminous appendage of the sun, called the corona, will become visible.

Its figure will be very irregular, and its light very mild, — in some parts near the edge of the moon it may appear quite dazzling, while in other parts it will be extremely faint, and the streamers or filaments will appear to have no definite limit.

This halo, or corona, can be seen only during a total eclipse, and it never

looks twice alike. Figs. 1, 2, and 3 give some idea of its appearance during past eclipses.[1]

The corona of the eclipse of 1889 is not likely to resemble these in any particular; and they are introduced here to give a general idea of the sort of thing to look for, and to afford the observer an opportunity for practice beforehand in drawing forms similar to those he may see during the approaching eclipse.

In addition to the mild white light of the corona, there may also be seen a few points of more brilliant light, but of a reddish tinge, appearing close to the edge of the moon. These are the solar protuberances, and they can be advantageously observed only with costly astronomical instruments. The observer need not make any record of these.

Uses of Observations of the Eclipse.

Much assistance will be rendered to astronomers who are studying the corona, if outline drawings of the whole, or any part of it, are made, as indicated further on. A part of the corona may be a sort of solar atmosphere, and is due to the presence of shining or luminous gas, but other parts seem to have no necessary connection with the sun. It is hoped that the observations of this eclipse may help to decide these and other points of interest.

If the observer is located far from the central line, the duration of total eclipse is very much shortened. Thus there will not be sufficient time for making sketches of the corona.

If the observer is located near the northern edge of the shadow path or near its southern edge, he can still make observations which will be very useful to astronomers in another way. All he has to do is to note by the watch how long a time it is from the instant the last ray of sunlight disappears, to the time the first ray of sunlight comes into view after the total eclipse is over. This will be an interval of time only a few seconds long; but with some other details mentioned subsequently, it will help astronomers in making very accurate predictions of the position of the moon in future years.

For further reference, the different kinds of observation are here classified.

Classes of Observation desired.

Class A. — Sketches of the Entire Corona.

" B. — Sketches of the Corona near the North and South Poles of the Sun's Disk.

" C. — Sketches of the Outer Corona.

" D. — Observations of the Duration of Total Eclipse.

[1] Figs. 1, 2, 3, 4, and 5 are taken from Professor Langley's "New Astronomy," the publishers of which, Messrs. Ticknor and Company of Boston, have courteously permitted their use here.

Generally speaking, it will not be worth while to attempt either A, B, or C, if the observer is more than twenty-five or thirty miles from the central line. The observer would do well to attempt D in such case, though observations of this class are of most value when made very near the north and south limits of the shadow-path.

This printed circular will be received at a few places where several persons or parties may be found willing to undertake the work indicated. It is desirable to have many working on the same kind of observation at or near the same place. In such case they should be scattered over a considerable area, some hundreds or thousands of feet apart. In this way a single cloud will be less likely to interfere with the work of all. Each person or party must send off the observations or drawings without comparing with the work of others at the same place.

Class A. — The Entire Corona.

General drawings of the corona should all be on the same scale. A specimen paper suitable for making such a drawing is shown on the back of the titlepage. A similar sheet may be prepared from unruled paper having an unglazed surface. The straight lines are necessary to enable one to draw the different parts of the corona in their correct positions.

It is very desirable that the person who will draw the corona should have had some previous practice in sketching similar objects. Otherwise the duration of total eclipse will be found too short to enable one to draw the details of the corona accurately. To facilitate this work, set up the pictures of the corona in this pamphlet (Figs. 1, 2, and 3), at distances ranging between 15 and 25 feet, according to the quality of the eyes, and see how much of the detail of a single picture can be embodied in a rapid sketch.

The form of the streamers or filaments of the corona is most important; next, their size (estimated in fractions of the diameter of the dark disk in the centre, which represents the moon); third, their brightness; and lastly, their position around the edge of the disk.

In these practice-drawings it would be well to change the position of the picture occasionally, so that the eye will become accustomed to the appearance of the wisps of light, whether they are directed up or down. The time allowed for each sketch should not exceed the duration of totality in the actual eclipse, and this may be inferred accurately enough from the table on page 4.

To assist in drawing the coronal streamers in their accurate angular position around the edge of the moon, a plumb-line will be necessary. Suspend a weight by a strong white cord or thread in such a position that the observer, when looking at the corona, may see the cord cutting the dark body of the moon exactly in two. If it is likely to be windy during the eclipse, the weight should hang freely in a

basin of water; or, after the vertical direction of the cord has been found, it may be fastened at the bottom in that position. It is desirable, but not necessary, that the plumb-line be used in the practice-drawings to accustom the observer to its use during the eclipse.

The light of the corona may not be bright enough to make the drawing by, and it is well to provide artificial light which can be used in case it is found necessary.

Four or five minutes before the eclipse becomes total, close the eyes and turn them from the sun, so that they will become very sensitive to faint light. Take the position previously arranged for making the sketch, with the plumb-line hanging between the eye and the sun.

An attendant should watch the crescent of sunlight, and announce when the last ray has vanished. The observer then turns toward the sun and begins the drawing. If no one is present who can do this, the observer can himself look at the diminishing crescent through a piece of smoked glass,[1] taking great care that no direct sunlight shall strike the eye. This would be so dazzling as to make it impossible to see the faint details of the corona immediately afterward.

First, draw the faint outlines of the corona as far as they can be seen from the sun. It is very important to get their correct size relatively to the moon. The lines drawn outward from the black disk on the prepared paper will be found very useful in marking the accurate positions of the more prominent streamers of the corona. In making this sketch it will be best to reverse dark and white, letting the white paper represent the dark background of the sky, while the dark lines of the soft pencil will represent the bright lines of the corona.

Then sketch the outlines of the brighter parts of the corona all around the edge of the moon. If the corona seems to dazzle the eye, it may be well to view it through a piece of glass slightly smoked. The smoked glass should not be used unless the corona seems very bright, and even then it should be seen only through the thinnest part of the film.

After this is done, if sunlight has not yet reappeared, make a rapid general comparison of the whole drawing with the corona itself, to correct any possible errors. Do not try to make a second sketch during totality, as the time will be too short. The original must not be changed or corrected in any way after sunlight returns; but if the observer can retain the appearance of the corona in memory, a second

[1] This can be made of a small pane of good window-glass by holding it over the flame of a lamp or candle until a black film is deposited on it. If possible, it should be smoked so that the tint will be so dense at one end that the full light of the sun seen through it will not dazzle the eye; while at the other the film should be so thin that objects in an ordinarily lighted room may be seen distinctly through it. Smoke the glass as evenly as possible from one end to the other. Paste a narrow strip of thick paper across each end of the glass, on the smoked side, and lay on it a sheet of unsmoked glass of the same size. Then secure the two sheets together by a strip of paper pasted around the edges of both plates.

drawing may be made immediately on another sheet of paper, and sent with the original sketch. In this second drawing, black and white need not be reversed, but may be drawn exactly as they appeared in the sky.

The person drawing the corona should not attempt to note the exact time of the beginning and end of total eclipse. These data are of no use at points near the central line unless the exact error of the timepiece is known. If this has been ascertained, a separate observer should record these times, and should write out a description of the place where the observation was made, exactly as indicated under Class D, page 14.

The name of each observer should be placed on the margin of the drawing, also the name of the place where it was made. No drawing should be folded or creased; but all should be forwarded in a pasteboard roll or wrapped on a round stick or roller. After totality is over, and sunlight has begun to return, every observer who has been engaged in drawing will do well to watch carefully for the possible visibility of some part of the corona. If any parts can still be seen, note their position, shape, and size on a separate sketch, and state how long after totality they could be seen. A thinly smoked glass will be helpful in this observation.

Class B. — Coronal Details.

If a field-glass, spy-glass, or telescope of any size is available, the best use it can be put to is the observation of those parts of the corona near the poles of the sun. These will appear to the right of the top of the moon's edge, and to the left of the bottom. Supposing the entire corona to look somewhat like Fig. 3, the poles will be immediately recognized as the points which correspond to the top and bottom in this figure. In general, the corona will probably be less prominently marked near these points, but the details of the wisps of light will be more confused and complex; and as seen with the telescope, there may be a slight resemblance to Fig. 4, though these exact forms are not likely to reappear during the coming eclipse.

If the observer is north of the central line, he will get better results from drawing that pole of the corona which lies at the left of the lowest point of the moon's edge.

If the observer is south of the central line, he had best sketch the corona at the sun's northern pole, or that part which will appear to the right of the uppermost part of the moon's edge.

The telescope or spy-glass should be firmly strapped to a round, upright post, and pointed as nearly as possible in the right direction, just before the eclipse becomes total. This may be done by protecting the eye with the smoked or colored glass; and the corona may appear so bright that a very thin film of smoke will be found a help in looking at the parts close to the sun. A lighted lantern

should be at hand to illuminate the paper in case of necessity. Prepare the paper beforehand, with an arc of a circle on it, similar to Fig. 4. A plumb-line will be desirable, as described in Class A, in order to fix the angular position of the filaments; and the top or bottom of the sun, as the case may be, must be marked on the arc at some time during the progress of the sketch.

Unless the observer is used to rapid sketching, probably it will be better to attempt to draw the corona adjacent to a single pole only, and thus save the time which would otherwise be lost in re-pointing the telescope at the other pole. It is not important which pole he chooses; but if there are two telescopes at a given place which are to be used in this kind of observation, the observers should arrange between themselves beforehand to draw, one the upper pole, and the other the lower pole.

As much as possible of the complexity of forms should be rapidly sketched; and previous practice on the curved and interlacing forms of Fig. 4 will be serviceable. The exact amount of curvature in these forms is important; also the precise relations of all the filaments should be as accurately drawn as is found practicable. State the name of maker and size of the telescope, and the magnifying power, as near as known.

Do not alter the sketch in any respect after totality is over; but if other details than those in the sketch are accurately remembered, make a second drawing at once, and embody them in that. A written description of the appearance of the filaments may perhaps contain additional information of value; but if such is prepared, it should be done immediately after the eclipse is over.

Class C. — Outer Corona.

A sketch of the outer corona and its long streamers will be rather more difficult to make than the foregoing, and will require more preparation. Trustworthy drawings will, however, be very valuable; but no one can undertake this work to advantage unless the eyes are very sensitive to faint light.

Fig. 5 shows the appearance of these streamers during the eclipse of 1878. It is not absolutely certain that they will be visible during the eclipse of 1889; but they should be carefully looked for, taking the precautions indicated below. It will be well to practise the sketching of Fig. 5 in outline beforehand, so that any similar forms which will likely appear during the eclipse may be rapidly and accurately put on paper. For this purpose place it 8 or 10 feet from the eye.

The inner corona is so bright that if the eye looks at the eclipse directly, the faint light of the long streamers cannot be seen. In order to see them, therefore, it will be necessary to set up a disk in line with the eye and the sun, so as to screen the eye from the brighter light of the inner corona. Any round disk, cut

out of wood, pasteboard, or sheet iron, will answer the purpose; and it will be well to paint it a dead black, though this is not necessary.

Attach a slender rod or pole to the disk, and then fasten the whole securely to the gable of a house, the top of a telegraph pole, or some other object, so that it may be exactly in line with the sun at the time of totality. The rod or pole should be at least 3 or 4 feet long, and should be fastened up plumb. The view all around the disk should be unobstructed, except by the rod which supports it; especially on the east and west sides of the disk, there should be no objects within nearer range than 12 or 15 feet.

The size of the disk will vary with its distance from the eye of the observer; and he must first select the most available place for setting up the disk and making the observation, and then cut the disk of the right size to correspond with the distance from the eye at which it will be set up. This table will show the proper size for the disk to suit any distance from 20 feet to 90 feet.

Distance of Disk from the Eye.	Corresponding Diameter of Disk.	Distance of Disk from the Eye.	Corresponding Diameter of Disk.
20 feet.	4⅝ inches.	60 feet.	13⅞ inches.
25 "	5¾ "	65 "	14¾ "
30 "	6⅞ "	70 "	15⅞ "
35 "	8 "	75 "	17 "
40 "	9⅛ "	80 "	18⅛ "
45 "	10¼ "	85 "	19¼ "
50 "	11⅜ "	90 "	20⅜ "
55 "	12½ "		

Any distance within this range will be suitable, but an average distance of 50 to 70 feet will be somewhat preferable to either extreme.

Having set up the disk, the observer must next arrange for the exact position of the eye during the eclipse, as nearly as possible. This may be done in the following way. A few days before the eclipse, note where the shadow of the disk falls, at the hour when the eclipse is to be total on eclipse day. This time can be obtained nearly enough from the table on page 4.

The point where the centre of the shadow falls will be very near the position where the eye should be, when looking at the eclipse; its distance from the disk, of course, being that corresponding to the size of the disk. Cut out a light disk of diameter one inch larger than the disk attached to the pole, and mark its centre. Hold it so that the shadow of the first disk shall fall centrally upon it, at the time when the eclipse is to be total. Then make a permanent mark where the centre of the light disk is, by means of an index or pointer. In this

way the observer will know very nearly where to place the eye at the proper time, on eclipse day, and not lose any time in the operation.

The index should be fastened at its upper end, and point downward, the lower end of it coinciding as nearly as possible with the centre of the shadow of the dark disk. Each day before the eclipse, the position of the pointer should be verified; and it will be found that it must be moved down, and toward the west, a fraction of an inch each day. It is especially important that this test should be made on the two days immediately before the eclipse.

Prepare a sheet of paper for the drawing, putting a dark circle in the centre, similar to the figure at the front, but only one-half an inch in diameter. A lighted lantern should be provided, to illuminate the paper, as it may be necessary in making the sketch; but a shield must be placed over it, to keep its direct light from reaching the eyes of the observer.

Ten or fifteen minutes before the eclipse will become total, the observer must go into a very dark room, in order that the eyes may become as sensitive as possible. This room should be within a few feet of the point of observation. An assistant then announces when the last ray of sunlight has gone and the corona has made its appearance. Then, with eyes closed, the observer takes the position at the pointer. Not until sure that the eyes are in the correct position, close to the lower end of the pointer, should the eyes be opened.

In a few seconds the long, indefinite streamers of the corona will likely become visible, extending outward faintly a long distance to the left and somewhat upward; also to the right and somewhat downward. They may look a little like the long streamers in Fig. 5; but that is not certain.

All of the brighter part of the inner corona will be hidden behind the disk, when the eyes are kept in position at the end of the pointer; and while looking for the faint streamers, the observer should be particularly careful not to move the head up or down, or to the right and left, as this brighter light would then strike the eye, and spoil the chances of seeing the faint, outlying streamers.

If the eye catches a glimpse of these objects, first notice whether the bands are of the same width on both sides of the disk, whether they are as wide in any part as the disk is, and whether they extend to the same distance from the disk on both sides.

Be especially careful to observe how far out the streamers extend, estimating their length in diameters of the disk. Note also their angular direction, relatively to the vertical pole which supports the disk. Sketch all these points as rapidly as possible. Also observe whether the streamers on both sides form parallel bands of light, or whether they are slightly divergent, as in the lower part of Fig. 5; also whether they are equally bright throughout, or whether they are quite bright in some parts, and very faint in others.

All details of their structure should be as carefully recorded as possible, in the

rapid sketch; and the observer should make out, if practicable, whether the ends of the streamers are alike — or different, somewhat resembling Fig. 5.

The sketch actually made during the eclipse should not under any circumstances be altered afterward; but if the observer saw additional features which he can carry in memory, these may be embodied in a second drawing which should be finished immediately. Descriptions of certain features by letter will be valuable, if the observer could not succeed in drawing them satisfactorily. The sketches should be sent off without any comparison with the similar work of others. State the size of the dark disk, and its distance from the eye.

Class D. — Simple Duration of Totality.

To make this observation to good advantage, the observer should be located within a few miles of the north or south edge of the shadow-path. The instructions here following are essentially the same as those prepared by Professor Newcomb for the Eclipse of 1878.

Instruments.

The only indispensable instrument is a good watch, provided with a seconds-hand, and having a white face. The minute-hand should be carefully set so as to be on an exact minute when the seconds-hand is at 60^s. This being done, it is no matter how far wrong the watch may be.

A good auxiliary will be a common spy-glass lashed to a round post, so as to be steady enough to give an easy view of the sun. To lessen the brilliancy of the sun, cover the object-glass with a cap having a round hole three fourths of an inch in diameter cut in its centre. The spy-glass will be worse than useless unless one is accustomed to its use, and has it fastened so as to be steady. An opera-glass held in the hand might also serve a good purpose. A smoked glass should also be prepared, but a part of the glass should be only very lightly smoked. See foot-note, page 7.

Arrangement for Observation.

Each observation should be made by a party of three persons. Only one instrument of each kind, watch, glass, etc., is needed by a party. A station should be selected where they will be free from all interruption, either in the open air or at an open window facing west. One, at least, of the party must have a pencil and note-book in hand to record the time.

The Observation.

When the visible part of the sun is reduced to the narrowest crescent, the holder of the watch, keeping his eye on its face, will begin to count the seconds

aloud. The observers of each party should practise beforehand the counting, calling, and recording. The holder of the smoked glass, with or without the spy-glass, will watch for the last ray of true sunlight, being careful to look through the brightest part of the glass which the eye will bear without inconvenience. The third observer, if there be one, will look for the disappearance of sunlight with the naked eye, and stand ready with pencil and paper to record the time. When the last ray of the sun has disappeared, the observer with the glass will call time; and the exact second at which the call was given must be immediately written down. The minute, also, must be carefully noted and recorded. The observers will then await the return of sunlight, the count of seconds being kept up, if the face of the watch can be seen, which it probably can, when held so that the light of the corona shall fall upon it.

The first flash of true sunlight will seem to burst out suddenly, and the minute and second of its appearance must be recorded with the same care as the time of disappearance. The difference of the two times gives the duration of totality.

If the observer has a stop-watch, he can readily record the contacts without any assistance. Set the stop-watch at 0^m 0^s, and at the instant of the beginning of total obscuration, start it. When totality ends, stop the watch, and its reading will then furnish the quantity desired.

Special Precautions.

In judging the beginning of totality, there is danger of error from two sources. The first is that the sun's crescent may become so narrow as to become invisible through the smoked glass, if it be too dark, several seconds before it is really all covered; and thus the observer may call "time" too soon. Such a mistake may be detected and corrected by the third observer, looking on with the naked eye, if the following circumstance be attended to: —

The beginning of total eclipse is marked by a very rapid increase in the darkness caused by the advent of the moon's shadow. If, then, the darkness increases more rapidly after time is called than it did before, time was called too soon, and must be repeated. The other danger is of the opposite kind, and should be equally avoided. It is that the light of the brilliant rose-colored protuberances which surround the dark body of the moon during the total eclipse may be mistaken for sunlight, and thus the critical moment be suffered to pass. In this case each observer must determine separately as to the exact second at which it ceased to grow darker; and if they agree within one or two seconds, the time judged may be supposed correct, and each one's estimate may be written down separately. The observer with the smoked glass will be more liable to the former of these mistakes; the naked-eye observer, to the latter.